A Series-based group stock portfolio optimization approach using the grouping genetic algorithm with symbolic aggregate Approximations

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ABSTRACT

Stock portfolio optimization is both an attractive research topic and a complex problem due to the rapidly changing economy. Based on optimization techniques, many algorithms have been proposed to mine different portfolios. In the previous approach, a group stock portfolio (GSP) was derived based on the investors' objective and subjective requests by the grouping genetic algorithm. Stocks were divided into groups, with those in the same group being similar. The benefit of using a GSP is that investors can replace any stock that they do not like with substitute stocks in the same group. To increase the similarity of stocks in groups, stock price series are taken into consideration, and an enhanced approach is proposed to derive a series-based GSP that can be used to provide more actionable stock portfolios to investors making decisions. In chromosome representation, grouping, stock and stock portfolio parts are used to represent a GSP as did the previous approach. To increase the return and similarity of a GSP, the stability factor is designed based on cash dividends, and the unit price balances are utilized as well. Because the dimension of stock price series is high, the symbolic aggregate approximation (SAX) and extended symbolic aggregate approximation (ESAX) are selected to transform data points into symbols. Then, the series distance factor is presented to evaluate the similarity of stock price series in groups of a GSP. By using the new factors and the existing factors in the previous approach, two new fitness functions are developed to evaluate the quality of chromosomes. Experiments on a real-world dataset were conducted to show the merits of the proposed approach using the two fitness functions with SAX and ESAX. The results show that the return on investment (ROI) of the proposed approach using the fitness functions with SAX is approximately 16% to 18% better than the ROI obtained with ESAX. However, the proposed approach with ESAX achieves better group similarity than does SAX.

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1. Introduction

Investing continues to be an attractive issue because numerous factors influence the financial markets; consequently, many derivatives can be selected [20, 22, 26, 30]. In other words, investors have many choices when creating a portfolio. In general, two objective measurements, the value at risk (VaR) and return on investment (ROI), are utilized to evaluate the quality of a portfolio. Because many factors affect the return of a given portfolio, a sophisticated approach for deriving a portfolio that considers different factors is needed. Using the mean-variance (M-V) model [24], many optimization algorithms have been proposed to mine portfolios [2, 4, 9, 21, 23, 29]. Although many stock portfolio optimization approaches have been proposed, these have been designed only to derive stock portfolios. However, deriving a stock portfolio is insufficient because users may not purchase the suggested stocks for various reasons. For example, the stock price of the suggested stock may be too high. When such situations occur, substitute stocks should be suggested. Hence, in the previous approach, an algorithm was proposed to mine the group stock portfolio (GSP) using the grouping genetic algorithm (GGA) [12]. Below, an example is used to illustrate the GSP, demonstrating the motivation of this work. Assuming that the twelve stocks are divided into four groups and that three groups will be purchased, the possible stock price series of the three purchased groups in the derived GSP are shown in Fig. 1.

As Fig. 1 shows, the stock price series in group G₄ are similar. However, we also understand that some of the stock price series in G₁ and G₂ are dissimilar. Taking G₁ as an example, we can see that stock symbol 2317 is different from other stocks. Hence, the
motivation of this paper is to improve the similarity of stock price series in groups. The ideal grouping result is shown in Fig. 2.

Fig. 2 shows stock price series of stocks in groups that are similar. Hence, the aim of this paper is to mine a GSP that not only has similar stock price series in groups but also high returns. To achieve this goal, the stock price series, which is a type of time series, is considered in this study. Because the number of data points of a time series is typically large and extracting knowledge from it may time-consuming, dimensionality reduction techniques are needed to speed up the mining process. Two dimensionality reduction techniques for time series, symbolic aggregate approximation (SAX) [23] and extended symbolic aggregate approximation (ESAX) [25], are utilized in the proposed approach. They first normalize the given time series. Then, utilizing piecewise aggregate approximation (PAA), the normalized time series is reduced to \( k \) points. Finally, the \( k \) points are transformed into \( k \) and \( 3k \) symbols for SAX and ESAX, respectively, according to the given alphabet size. Many approaches have been presented for different applications based on them, e.g., classification [37] and financial data [1].

In this paper, stock price series are taken into consideration, and an enhanced approach is proposed to mine a GSP using GGA. The proposed approach first encodes the GSP into a chromosome using three components: grouping, stock and stock portfolio parts, as did the previous approach [12]. In the previous approach, portfolio satisfaction and group balance were utilized to evaluate the fitness of a chromosome. Portfolio satisfaction was used to measure the profit and satisfaction of objective and subjective requests given by investors, while the aim of group balance was to ensure that the number of stocks in the groups were similar. In the proposed approach, a modified portfolio satisfaction is designed by adding the stability factor, which is used to avoid the selection of high-risk stocks in a GSP according to cash dividends. To evaluate the similarity of stock price series, the series distance factor is then developed. Using modified portfolio satisfaction, group balance and series distance, the first fitness function is presented to
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